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U.S. Department of Transportation

Federal Aviation Administration Specification

CABLE, FIBER OPTIC, MULTIMODE, and SINGLE-MODE, MULTIFIBER

1. SCOPE AND CLASSIFICATION.

1.1 Scope. - This specification contains requirements for three classes of multi-fiber, optical wave-guide, to be used in the transmission of control/communication signals at airports. The first is a dual spectral-window (1310nm/1550nm), single-mode fiber; the second is a multimode, graded index, 1300 nm spectral window 50/125um fiber; and the third is a multimode, graded index, 1300nm spectral window, 62.5/125 um fiber. This specification may be used for fiber-optic cable acquisition for installation at facilities other than airports.

1.2 Classification. - Three types of each class of cable are defined by this specification.

Type A	Six, twelve, or twenty-four fiber, non-armored, totally dielectric cable including interstice water-intercepter compound and buffer-tube gel-filling, with a central strength member.
Type B	Type B cable includes a nylon or polyvinylidene flouride (Kynar ®) exterior sheath to provide protection from hydrocarbon fuels that is applied over an inner sheath of polyethylene. Except for the sheathing it is the same as Type A cable.

Type C Two-fiber (duplex) tight buffer, cable for interior use having a helically wrapped or braided aramid reinforcement, and sheathed with a non-halogenated, low smoke producing material. It shall be in accordance with Article 770, "Optical Fiber Cable" of National Fire Protection Association (NFPA) Publication 70 (National Electrical Code). See 6.2 for further information.

1.3 Environmental conditions. - Types A and B cable shall meet the following environmental requirements:

1.3.1 Temperature.

1.3.1.1 Operating. -40° C to +70° C (-40° F to +158° F).

1.3.1.2 Storage. -40° C to +70° C (-40° F to +158° F).

1.3.1.3 Installation. 0° C to +40° C (+32° F to +104° F).

1.3.2 Immersion.

1.3.2.1 Water. - The cable shall not be damaged by continuous immersion in water: i.e. ground or duct water.

1.3.2.2 Hydrocarbon fuels. - The performance of Type B cable shall not be affected by continuous immersion in hydrocarbon fuels.

1.3.3 Installation environment.

1.3.3.1 Ducts. - Applicable.

1.3.3.2 Direct-earth burial. - Not Applicable.

1.3.3.3 Aerial. - Applicable. Will require external messenger wire.

1.3.3.4 Marine. - Not applicable.

1.4 Definition of terms.

1.4.1 Optical terms. - The following are used herein and are as defined in ANSI EIA/TIA 440A:

Cable cut-off wavelength.

Dual spectral-window

Fiber Bandwidth

Graded index optical wave-guide

Mode-field diameter

Numerical aperture

Peak-wavelength

Single-mode optical fiber

Zero-dispersion wavelength

1.4.2 Zip-cord. - A duplex communication cable comprised of two individual conjoined cables. Each cable is comprised of a tight buffered fiber, an aramid yarn strength member, and a thermoplastic jacket. The cables are conjoined in such a manner that intentional bifurcation is easily effected. The "zip-cord" incorporates a method to distinguish the fibers.

1.4.3 Units. - The following measurement units are used in this specification:

decibel (dB) = 10 times logarithm to the base 10 of a power ratio (P1/P2).

gigahertz (Ghz) = 10^{9} hertz = a unit of frequency equal to one billion hertz.

kilometer (km) = 10^{3} meters = one thousand meters

megahertz (MHz) = 10^{6} hertz = one million hertz

micron (um) = $10^{-6 \text{ meter}}$ = one millionth of a meter

millimeter (mm) = 10^{-3} meter = one thousandth of a meter

nanometer (nm) = 10^{-9} meter = one billionth of a meter

picoseconds (ps) = $10^{-12 \text{ seconds}}$ = one trillionth of a second.

Newton (N) = The force required to move a one kilogram mass one meter per second squared; a metric unit of force equivalent to 0.225 pound-force.

2. APPLICABLE DOCUMENTS.

2.1 General. - The following documents form a part of this specification to the extent specified herein. In the event of a conflict between this specification and the following documents, this specification shall have precedence.

2.2 American National Standards Institute / Electronic Industries Association / Telecommunication Industry Association ANSI / EIA/TIA standards.

EIA/TIA-440A, Fiber Optic Terminology, 1988

EIA/TIA-455, Fiber Optic Test Procedures (FOTP):

FOTP 3A	Procedures to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components, 1989
FOTP 25A	Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies, 1989
FOTP 30B	Frequency Domain Measurement of Multimode Optical Fiber Information Transmission Capacity, 1991
FOTP 31B	Fiber Tensile Proof Test Method, 1990
FOTP 33A	Fiber Optic Cable Tensile Loading and Bending Test, 1987
F/OTP 37A	Fiber Optic Cable Bend Test Low and High Temperature, 1993
FOTP 41A	Compressive Loading Resistance of Fiber Optic Cables, 1993
FOTP 47B	Output Far-Field Radiation Pattern Measurement, 1992
FOTP 51A	Pulse Distortion Measurement of Multimode Glass Optical Fiber Information Capacity, 1991
FOTP 58A	Core Diameter Measurement of Graded-Index Optical Fibers, 1990
FOTP 59	Measurement of Fiber Point Defects Using an OTDR, 1989
FOTP 61A	Measurement of Fiber or Cable Attenuation using an OTDR, 1989
FOTP 78A	Spectral Attenuation Cutback Measurements for Single-Mode Optical Fibers, 1990
FOTP 81A	Compound Flow (Drip) Test for Filled Fiber Optic Cable, 1991
FOTP 82B	Fluid penetration Test for Fluid Blocked Fiber Optic Cable, 1992
FOTP 164A	Single-Mode Fiber, Measurement of Mode Field Diameter by Far Field Scanning, 1991

FOTP 167A Mode Field Diameter Measurement, Variable Aperture Method in the Far Field, 1992

FOTP 168A Chromatic Dispersion Measurement of Multimode Graded Index and Single-Mode Optical Fibers by Spectral Group Delay in the Time Domain, 1992

FOTP 170 Cable Cutoff Wavelength of Single-Mode Fiber by Transmitted Power, 1989

FOTP 173 Coating Geometry Measurement for Optical Fiber, Side-View Method, 1990

FOTP 176 Method for Measuring Optical Fiber Cross-Sectional Geometry by Automated Gray Scale Analysis, 1993

ANSI/EIA/TIA 598, Color Coding of Fiber Optic Cables

2.3 American National Standards Institute/Insulated Cable Engineers Association (ANSI/ICEA) Publications.

ANSI/ICEA S-87-640-1992, Standard for Fiber Optic Outside Plant Communications Cable

2.4 ANSI/International Standards Organization/ American Society for Quality Control (ANSI/ISO/ASQC).

ANSI/ISO/ASQC Q9003-1994, Quality Systems-Model for Quality Assurance in Final Inspection and Test

2.5 National Electrical Manufacturers Association (NEMA).

NEMA WC 26-1984, Wire and Cable Packaging

2.6 National Fire Protection Association (NFPA).

NFPA 70-1996, National Electrical Code (Revision, 1996)

2.7 Document sources. - Copies of this specification may be obtained from the contracting officer in the FAA office issuing the Invitation for Bid (IFB) or Request for Proposal (RFP). Requests should fully identify this specification by number, title, date-of-issue, etc., and should identify the IFB, RFP or contract involved, or other use to be made of the specification.

ANSI/EIA and ANSI/EIA/TIA standards may be obtained from the Electronic Industries Association/Telecommunications Industry Association, 2001 Pennsylvania Avenue NW, Washington, DC 20006.

ANSI/ICEA specifications may be obtained from the Insulated Cable Engineers Association, P.O. Box P, South Yarmouth, MA 02664.

ANSI/ISO/ASQC specifications may be obtained from the American Society for Quality Control, 611 East Wisconsin Avenue, P.O. Box 3005, Milwaukee, WI 53201-3005.

NFPA specifications may be obtained from the National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269.

3. REQUIREMENTS.

3.1 Introduction. - The fiber optic cable specified herein will be an integral part of a FAA on-airfield communication system. The requirements defined herein are intended to result in a cable with a reliability appropriate to the critical nature of the application.

3.2 Materials. - If material for a cable component is stipulated, it shall be as specified herein. If the material for a cable component is not stipulated, it shall be entirely suitable for the application. The manufacturer shall certify that all synthetic substances were produced from virgin compounds.

3.3 Workmanship. - The cable shall be free of any imperfections that may affect its performance or survivability in the environment stipulated in section 1.3.

3.4 Fiber and cable.

3.4.1 Multimode Fiber (50/125 um). - The 50/125 um multimode fiber shall be of an all silica-based composition, with a core having a fully-graded refractive index profile and a transmission window at 1300 nm.

3.4.1.1 Core diameter. - The core diameter shall be 50 ± 3 um as determined by FOTP 58A.

3.4.1.2 Cladding diameter. - The cladding diameter shall be 125.0 ± 2.0 um as determined by FOTP 176.

3.4.1.3 Core-cladding concentricity (offset). - The core-cladding offset shall not exceed 3 um as determined by FOTP 176.

3.4.1.4 Core non-circularity. - The non-circularity of the core shall not exceed 5.0 % as determined by FOTP 176.

3.4.1.5 Protective coating. - The coating diameter shall be 250 ± 15 um as determined by FOTP 173. The protective coating shall be easily removed by common mechanical or chemical means.

3.4.1.6 Numerical aperture. - The numerical aperture of the fiber shall be 0.20 ± 0.015 as determined by FOTP 177 with FOTP 47B method A or B.

3.4.1.7 Attenuation. - The attenuation of the cabled fiber, as determined by FOTP 61A shall not exceed 0.8dB/km at 1300 nm at 20° C (68° F). The Optical Time Domain Reflectometer (OTDR) trace shall be substantially linear. Localized variations/discontinuities in the OTDR trace shall not exceed 0.2dB as determined by using FOTP 59. The attenuation resulting from the hydroxyl ion absorption shall not exceed the attenuation at the nominal zero dispersion wavelength by more than 3dB as determined by FOTP 61A.

3.4.1.8 Zero-dispersion wavelength. - The zero-dispersion wavelength shall be 1307 nm ± 10 nm as determined by FOTP 168A.

3.4.1.9 Zero-dispersion slope. - The zero-dispersion slope of the fiber shall not exceed 0.101 ps/nm^2-km as determined by FOTP 168A.

3.4.1.10 Optical bandwidth. - The -3dB optical bandwidth, as determined by FOTP 30B or FOTP 51A shall not be less than 1,000 Mhz-km. For fiber lengths greater than one kilometer, the magnitude of the length-normalizing exponent shall be assumed not to exceed 0.85.

3.4.1.11 Tensile strength. - The tensile strength of the fiber as measured by FOTP 31B, shall not be less than 0.69 GN/m^2.

3.4.1.12 Temperature dependence of attenuation. - The temperature dependence of attenuation as determined by FOTP 3A, shall not exceed 0.5 dB/km over the temperature range of - 40^0 C to + 60^0 C (- 40^0 F to + 140^0 F).

3.4.2 Multimode Fiber (62.5/125 um). - The 62.5/125 um multimode fiber shall be of an all silica-based composition, with a core having a fully-graded refractive index profile and a transmission window at 1300 nm.

3.4.2.1 Core diameter. - The core diameter shall be 62.5 ± 3.0 um as determined by FOTP 58A.

3.4.2.2 Cladding diameter. - The cladding diameter shall be 125.0 ± 2.0 um as determined by FOTP 176.

3.4.2.3 Core-cladding concentricity (offset). - The core-cladding offset shall not exceed 3 um as determined by FOTP 176.

3.4.2.4 Core non-circularity. - The non-circularity of the core shall not exceed 5.0% as determined by FOTP 176.

3.4.2.5 Protective Coating. - The coating diameter shall be 250 $\pm$ 15 um as determined by FOTP 173. The protective coating shall be easily removed with common mechanical or chemical means.

3.4.2.6 Numerical aperture. - The numerical aperture of the fiber shall be 0.275 $\pm$ 0.015 as determined by FOTP 177 with FOTP 47 method A or B.

3.4.2.7 Attenuation. - The attenuation of the cable fiber, as determined by FOTP 61 shall not exceed 1.0 dB/km at 1300 nm at 20^0 C (68^0 F). The Optical Time Domain Reflectometer (OTDR) trace shall be substantially linear. Localized variations/discontinuities in the OTDR trace shall not exceed 0.2 dB as determined by using FOTP 59. The attenuation resulting from the hydroxyl ion absorption shall not exceed the attenuation at the nominal zero dispersion wavelength by more than 3 dB as determined by FOTP 61A.

3.4.2.8 Zero-dispersion wavelength. - The zero-dispersion wavelength shall be within the range 1320 nm to 1365 nm as determined by FOTP 168A.

3.4.2.9 Zero-dispersion slope. - The zero-dispersion slope of the fiber shall not exceed 0.110 ps/nm^2-km within the range 1320 nm to 1348 nm nor shall it exceed (1458 -λ_0)/1000 ps/nm^2-km within the range 1348 nm to 1365 nm as determined by FOTP 168A.

3.4.2.10 Optical bandwidth. - The -3dB optical bandwidth, as determined by FOTP 30B or FOTP 51A shall not be less than 500 Mhz-km. For fiber lengths greater than one kilometer, the magnitude of the length-normalizing exponent shall be assumed not to exceed 0.85.

3.4.2.11 Tensile strength. - The tensile strength of the fiber as measured by FOTP 31B, shall not be less that 0.69 GN/m^2.

3.4.2.12 Temperature dependence of Attenuation. - The temperature dependence of attenuation as determined by FOTP 3, shall not exceed 0.5 dB/km over the temperature range of - 40^0 C to + 60^0 C (- 40^0 F to + 140^0 F).

3.4.3 Single-mode fiber. - The single-mode fiber shall be dual spectral-window, matched-clad, of all silica based composition.

3.4.3.1 Core-cladding concentricity (offset). - The core-cladding offset as determined by the method described in FOTP 176, shall not exceed 0.8 um.

3.4.3.2 Mode-field diameter. - The mode-field diameter shall be within the range of 8.8 um to 9.3 um as determined by either FOTP 164A or FOTP 167A.

3.4.3.3 Cut-off wavelength of cabled fiber. - The cut-off wavelength of the cabled fiber shall be less than 1260 nm as determined by FOTP 170, Test Procedure, method A or B.

3.4.3.4 Zero-dispersion wavelength. - The zero-dispersion wavelength shall be within the range: 1300 NM to 1324 nm as determined by FOTP 168A. The median zero-dispersion wavelength shall be 1310 $\pm$ 3nm.

3.4.3.5 Zero-dispersion slope. - The maximum value for the zero-dispersion slope shall not exceed 0.093 ps/nm^2-km as determined by FOTP 168A.

3.4.3.6 Attenuation. - The attenuation of the cabled fiber, as determined by FOTP 78A shall not exceed 0.5dB/km at 1310 nm nor shall it exceed 0.3dB/km at 1550 nm at 20° C (68° F).

The attenuation profile as measured using an Optical Time Domain Reflectometer (OTDR) shall be substantially uniform. Localized variations/discontinuities in the OTDR profile shall not exceed 0.1dB as determined by FOTP 59. The attenuation resulting from the hydroxyl ion absorption shall not exceed the attenuation at the nominal zero dispersion wavelength by more than 2.1dB as determined by FOTP 78A.

3.4.3.7 Cladding diameter. - The cladding diameter shall be 125 $\pm$ 1 um as determined by FOTP 176.

3.4.3.8 Non-circularity. - The non-circularity of the cladding shall not exceed 1.0 % as determined by FOTP 176

3.4.3.9 Tensile Strength. - The tensile strength of the fiber as measured by FOTP 31, shall not be less than 0.69 GN/m^2

3.4.3.10 Protective coating. - The outside diameter of the protective coating shall be 250 $\pm$ 15 um as determined by FOTP 173. The protective coating shall be easily removed by common chemical or mechanical means.

3.4.3.11 Temperature dependence of attenuation. - The temperature dependence of attenuation, as determined by FOTP 3, shall not exceed 0.2 dB/km over the temperature range -40° C to +60° C (-40° F to +140° F).

3.4.4 Cable performance.

3.4.4.1 Cable storage (Type A and Type B). - There shall be no deterioration of the cable, fiber integrity, or optical performance due to outdoor storage of the cable on the shipping reel.

3.4.4.2 Installation bending radius and pulling force. - Type A and Type B cable shall perform satisfactorily under the following installation conditions:

a) Bending radius of 20 times cable diameter

b) Pulling force equal to or less than 2700 Newtons.

3.4.4.3 Long-term bending radius and post installation conditions. - Type A and Type B cable shall perform satisfactorily under the following post installation conditions:

(a) Bending radius of 15 times cable diameter

(b) Residual tension equal to or less than 600 Newtons.

3.4.4.4 Crush resistance. - Type A and Type B cable shall withstand a compressive load of 220 N/cm. When tested in accordance with FOTP 41A, the change in attenuation shall not exceed 0.4 dB during loading and 0.2 dB after loading at 1550 nm for single mode fiber and 1.0 dB during loading and 0.4 dB after loading at 1300 nm for multimode fiber.

3.4.4.5 Impact resistance. - When tested in accordance with FOTP 25A, Type A and Type B cable shall withstand 25 impact cycles. The change in attenuation shall not exceed 0.2 dB at 1550 nm for single-mode fiber, (0.3 dB at 1300 nm for multimode fiber.)

3.4.5 Cable construction.

3.4.5.1 Unspliced length. - The un-spliced cable length on each delivered reel shall be 3.0 km in accordance with 5.1 unless otherwise specified. Reference ICEA S-87-640-1992 sections 7.3 and 7.4.2.

3.4.5.2 Central strength member. - The central strength member of Type A and Type B, cable shall be totally dielectric and fully compatible with other cable components. Reference ICEA S 87-640-1992, section 9.1.6.

3.4.5.3 Fiber Protection. - For Type A and Type B cables, buffer tubes containing a water-blocking gel shall be used to provide a moisture-free environment for the fiber. Each buffer tube shall be the same diameter, and shall contain from one to twelve fibers as necessary to meet the fiber count stated in the contract. The buffer tubes shall be stranded about the central strength member at a lay length that will ensure a stress free environment for the fiber over the specified range of environmental conditions (see 1.3). Type C cable shall be of a tight buffer tube design, reference ICEA S-87-640-1992 section 4.1.1, zip-cord design, reference ICEA S 87-640-1992,sections 6.15 and 9.1.9.

3.4.5.3.1 Buffer tubes. - The buffer tube material shall be fully compatible with other materials used in the cable. The nominal tube outer diameter shall be less than or equal to 3.0 mm. The loose buffer tubes shall break easily and cleanly when circumscribed by a sharp knife or razor blade and bent. Buffer tubes shall be color coded in accordance with ANSI/EIA/TIA 598. For Type C cables, the force required to remove 15mm $\pm$ 1.5 mm of the buffer and coating composite structure shall be less than 13.3 N when tested in accordance with FOTP 178.

3.4.5.3.2 Buffer tube water- blocking gel. - The buffer tube water-blocking gel filling compound in Type A and Type B cable buffer tubes shall prevent water and/or water vapor from entering at temperatures up to 65° C (149° F). The gel shall be neither toxic nor a dermal irritant. If colored, the coloring shall not interfere with the identification of the color-coded buffer tubes. The gel shall be fully compatible with the other materials used in the cable. It shall be easily removable with a clean, dry cloth. Any residual gel shall be easily removable by a commonly used solvent.

3.4.5.4 Interstice water-interceptor. - The cable shall include a super absorbent polymer based (or, with the approval of the FAA contracting officer, an alternate) gel compound to intercept water in the interstices formed by the structural components of the cable core.

3.4.5.5 Tape wrap. - The buffer tubes shall be held in place by a helically wrapped tape or binder compatible with the buffer tube and water intercepting gel compound.

3.4.5.6 Exterior sheath (Type A). - The sheath shall be a continuous extruded polyethylene having a nominal thickness of 1.40 mm with no voids or inclusions. It shall be of a medium density polyethylene (MDPE) conforming to ASTM D 1248, Type II, Class C, Category 4 or 5, Grade J4.

The carbon black content shall be 2.6 $\pm$ 0.25 % by weight in accordance with ASTM D 1603, to provide aging characteristics consistent with a 40-year cable life. The average of the thickness shall not be less than 1.2 mm nor shall it be greater than 1.6 mm. The thickness at any point shall not be less than 1.0 mm.

3.4.5.7 Inner sheath (Type B). - The inner sheath shall be a continuous extruded polyethylene with no voids or inclusions. The thickness at any point shall not be less than 0.4 mm. The sheath material shall have aging characteristics consistent with a 40-year life expectancy of the cable.

3.4.5.8 Exterior sheath (Type B). - The exterior sheath shall be a continuous extruded "nylon" or polyvinylidene flouride with a nominal thickness of 1.15 mm with no voids or inclusions. The sheath material shall be certified as providing effective protection and minimal visual evidence of surface or dimensional changes from jet fuel as determined by ASTM D 543 at 150 ^{0} F. The average of the thickness shall not be less than 1.0 mm nor shall it be greater than 1.3 mm. The thickness at any spot shall not be less than 0.80 mm. The eccentricity of the finished cable, including both the inner and outer sheath shall not exceed 40 % as determined by ASTM D 4565 section 8. The carbon black contents shall be 2.6 $\pm$ 0.25 % by weight in accordance with ASTM D 1603 sections 6 and 7 to provide aging characteristics consistent with a 40-year cable life.

3.4.5.9 Exterior sheath (Type C). - The exterior sheath shall be a flame-retardant, non-halogenated, low smoke-producing material suitable for interior installation in cable trays or electrical raceways per NFPA 70, Article #770.

3.4.5.10 Rip cords (Type A and Type B). - Ripcords shall be incorporated to facilitate sheath removal.

3.4.5.11 Cable identification. - The exterior sheath of Type A and Type B cables shall be permanently marked every meter with the manufacturer's name, sequential meter markings, year and month of manufacture, and a telecommunication handset symbol, as required by section 350-G of the National Electrical Code (NEC) and NFPA 70, Article # 770. Other printed information may be required by the contract. Type C cables will, as a minimum, be permanently marked with the manufacturers name or UL File number, UL Type Listing, month and year of manufacture, and sequential length markings every meter.

4. QUALITY ASSURANCE PROVISIONS.

4.1 Quality control provisions. - The manufacturer shall comply with the requirements of ANSI/ISO/ASQC 9003. All tests shall be performed by the Contractor and shall be witnessed by the Government. If Government witnessing is waived, the contractor shall furnish two copies of certified test data. The cable will not be accepted by the Government until the test data, certified by a properly authorized official of the Contractor to be true, correct, complete and satisfying the specification requirements, has been submitted to and approved by the Government. All tests shall be performed at the time of manufacture. Any reel of cable or specimen offered for inspection but failing to meet the requirements of the test may not be re-offered for a retest without approval of the Contracting Officer.

4.2 Test samples. - Testing shall be performed on the basis of sampling. The sampling is defined in 4.2.1 and 4.2.2.

4.2.1 Inspector's Samples. - When stipulated in the Invitation For Bid (IFB) or Request For Proposal (RFP), one 25 meter length of cable shall be cut from the end of reels to be selected randomly, with a maximum sampling of one sample per each 15 km. A minimum sample for orders less than 15 km is one sample. For example, an order for 150 km of fiber optic cable would be packaged on 50 3.0-km reels. A sample shall be taken at random from each lot of five reels, for a total of ten samples. Each sample will be identified by reel number, contract/order number, and specification number. The reels shall be numbered sequentially for this purpose in the order of manufacture.

4.2.2 Referee samples. - When stipulated in the IFB or RFP, samples of the completed cable not less than five meters long shall be supplied to an independent testing laboratory selected by the Contracting Officer. One sample shall be taken from one of the first five reels in an order, and an additional sample shall be taken from one of each additional ten reels or less of the order. In the example of 4.2.1, if referee samples were required, one would be taken from the first five reels, one each from the next four groups of ten reels, and one from the last five reels, for a total of six samples. Samples and reels shall be identified in accordance with 4.2.1. Shipment of samples, if required, will be done at Government expense. Packing samples and delivery to a common carrier will be at the Contractor's expense.

4.3 Cable testing.

4.3.1 Fiber. - All fibers in the finished cable shall have been tested prior to cabling in accordance with the definitions and procedures specified in the EIA/TIA-455 Fiber Optic Test Procedures (FOTP's) to determine if the fiber complies with the specifications of paragraph 3.4. When specified in the contract, the fiber manufacturer shall provide a certificate of compliance for the following properties where indicated by a "yes":

	multimode	single-mode
a) Core Diameter	yes	-
(b) Cladding Diameter	yes	yes
(c) Protective Coating Diameter	yes	yes
(d) Core-Cladding Concentricity	yes	yes
(e) Core non-circularity	yes	-
(f) Cladding non-circularity	yes	yes
(g) Tensile strength	yes	yes
(h) Numerical Aperture	yes	-
(i) Zero-dispersion wavelength	yes	yes
(j) Zero-dispersion slope	yes	yes
(k) Bandwidth	yes	-
(l) Mode-field diameter	-	yes
(m) Cut-off wavelength	-	yes

4.3.2 Cable assembly tests. - The tests described by 4.3.2.1 and 4.3.2.2 shall be performed on all fibers of every reel. The tests described by 4.3.2.3 through 4.3.2.11 shall be performed in accordance with the stipulations of 4.2.1. The Contracting Officer shall be notified in the event of failure to pass any test.

4.3.2.1 Optical attenuation. - The optical attenuation of the cable shall be validated in accordance with the requirements of 3.4.1.7 and 3.4.2.7 (multimode) and 3.4.3.6 (single-mode) on all fibers of every reel of finished cable. The test results for each reel shall be provided upon delivery in a sealed waterproofed envelope.

4.3.2.2 Optical bandwidth. - The -3dB end-to-end optical bandwidth of all fibers in all multimode cables shall be determined by FOTP 30B. For lengths greater than 1 km, the required -3dB end-to-end bandwidth shall be calculated from:

$$BW_{-3dB} \geq 1{,}000 \text{ Mhz/(length in kilometers)}^{.85}, \quad (50/125\text{um})$$

$$BW_{-3dB} \geq 500 \text{ Mhz/(length in kilometers)}^{.85}, \quad (62.5/125\text{um})$$

4.3.2.3 Temperature dependence of attenuation. - The temperature dependence of attenuation shall be determined by FOTP 3 (for 48 hours or when it is ensured that the cable has uniformly reached the test temperature) on all fibers of one reel of cable selected at random. Measurements shall be made at -40° C and +60° C, $\pm$2° C

4.3.2.4 Sheath thickness. - The thickness of the interior and/or the exterior sheath shall be as specified in 3.4.5.6, 3.4.5.7, and 3.4.5.8 when measured in accordance with ASTM D 4565, section 7.

4.3.2.5 Cable flexing. - The specimen(s) selected from the sample specified in 4.2.1 shall be prepared in accordance with FOTP 37A, except that a mandrel having a diameter up to 20 times the cable diameter shall be permitted. Test condition D (0° C and 40° C) of Table I of FOTP 37A shall suffice, as shall Test Level 2 (10 mandrel turns) of Table III. The test mass shall be in accordance with Table II.

4.3.2.6 Gel filling compound flow test. - Test specimens selected randomly from the samples specified in 4.2.1 shall be subjected to a gel filling compound flow test in accordance with FOTP 81A, Method B, at a temperature of 60° C $\pm$ 2° C (140° F $\pm$ 3.5° F). There shall be no evidence of gel compound flowing or dripping from any buffer tube or other cable component.

4.3.2.7 Water intercept tests. - Test specimens selected randomly from the sample specified in 4.2.1 shall be tested per FOTP 82B. There shall be no evidence of water leakage.

4.3.2.8 Cable pulling capacity test. - This test shall be performed in accordance with FOTP 33A. This test shall be a type acceptance test on a production run basis.

4.3.2.9 Sheath material properties certification. - The manufacturer shall certify that the extrusion process used for application of the sheathing compound complies with the recommendations of the compound supplier.

4.3.2.10 Crush resistance test. - Test specimens taken at random from the samples specified in 4.2.1 shall be subjected to the crush force specified in 3.4.4.4. The optical attenuation shall not

change from before the test to after the test in the tested sample.

4.3.2.11 Impact resistance test. - Test specimens taken at random from the samples specified in 4.2.1 shall be subjected to the impact force specified 3.4.4.5. The optical attenuation shall not change from before the test to after the test in the tested sample.

5. PREPARATION FOR DELIVERY.

5.1 Cable length per reel. - The specified length of cable shall be delivered on a non-returnable reel in one continuous length within a tolerance of: -0%, +5%, unless otherwise specified.

5.2 Cable protective wrap. - The outer layer of cable shall be completely covered with a reflective and water resistant wrap such as white water-resistant paper, white plastic, or aluminum foil.

5.1 Reel construction. - Reels shall have been constructed from previously-unused wood and in accordance with NEMA WC-26, Wire and Cable Packaging. Plywood reels are not acceptable. The reel shall protect the cable from all shipping hazards and shall provide long-term outdoor-storage protection from wind, sand, rain, snow and sunlight. The cable reels shall also comply with the requirements stipulated in ICEA S-87-640 paragraph 7.4.4, subparagraphs 7.4.4.1 through 7.4.4.4 inclusive, and paragraph 7.4.7. If access to the inner end of the cable is via a slot in the reel flange, the slot shall be covered with a rust-resistant metal plate. The plate shall be not less than 18-guage.

5.2 Reel lagging. - The reel shall be lagged with nominal two-inch by four-inch #2 common lumber from edge-to-edge around the full circumference of the reel. The lagging shall be strapped with two or more equally spaced steel bands.

5.4 Reel marking. - The contractor's name, contract number under which the cable was purchased, NSN, actual length and type of cable, and cable installation temperature range (prominently marked), shall be embossed or printed with indelible ink onto aluminum plates and securely fastened to each outer reel-flange with nails or screws. The minimum font size for reel markings shall be 28.

6. NOTES.

6.1 Note on information items. - The contents of the subparagraphs below are only for the information of the initiator of the procurement request and the Contracting Officer, intended to assist them in formulating a contract. They are not contract requirements, nor are they binding on either the Government or the contractor except to the extent to which they may be specified elsewhere in the contract as such. The contractor shall not rely on the information in these subparagraphs.

6.2 Type C cable. - Type C is intended to be any commercially available dual spectral-window, two-fiber (duplex), tight buffer, cable for interior use having a helically wrapped or braided aramid reinforcement, and sheathed with a non-halogenated, low smoke-producing material suitable for use in accordance with paragraph #770, NFPA-70. The test requirements of this specification are not applicable to this type.

6.3 Factory Inspection Option. - The IFB shall state that the Government shall have the option of witnessing production tests conducted at the factory (see paragraph 4.1). Regardless of whether the Government witnesses the production tests, the contractor shall furnish certified test reports and the manufacturers most recent Qualification Test Report.

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